

1 WE CLAIM:

Sub A<sub>1</sub> 2 1. A laterally translatable pressure staged shaft sealing mechanism comprising:

3 (a) a housing being exposed to a first fluid at a pressure P1;

4 (b) a relatively rotatable surface being located for relative rotation with respect to said housing;

5 (c) laterally translatable annular seal carrier means having laterally translatable movement  
6 relative to said housing responsive to lateral movement of said relatively rotatable surface;

7 (d) first and second annular resilient sealing elements being supported in axially spaced relation  
8 by said laterally translatable annular seal carrier means and having interference sealing relation with  
9 said laterally translatable annular seal carrier and said relatively rotatable surface and defining a staging pressure  
10 chamber between said first and second annular resilient sealing elements; and

11 (e) means communicating a second fluid at a staging pressure P2 to said staging pressure  
12 chamber at a pressure being a fraction of said pressure P1.

1 2. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) said laterally translatable annular seal carrier means being first and second seal carriers  
3 respectively supporting said first and second annular resilient sealing elements; and

4 (b) at least one of said first and second seal carriers being substantially hydraulically force  
5 balanced in the axial direction.

1 3. The laterally translatable pressure staged shaft sealing mechanism of claim 2, comprising:

2 (a) a bulkhead being located in sealed relation to housing and defining axially spaced annular  
3 seal carrier recesses; and

4 (b) said first and second seal carriers being located within said axially spaced annular seal carrier  
5 recesses.

1 4. The laterally translatable pressure staged shaft sealing mechanism of claim 3, comprising:

2 said bulkhead being substantially hydraulically force balanced in the radial direction.

1 5. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 said first and second annular resilient sealing elements establishing substantially equal sealing diame  
3 with said relatively rotatable surface.

1 6. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 said first and second annular resilient sealing elements establishing unequal sealing diameters with  
3 relatively rotatable surface.

1 7. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) a first fluid circulation passage for circulating said first fluid at said pressure P1 for cool  
3 of said first annular resilient sealing element; and

4 (b) a circulation passage for circulating said second fluid at said pressure P2 within said stag  
5 pressure chamber for cooling of said first and second annular resilient sealing elements.

1 8. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) a source of circulating coolant fluid at low pressure;

3 (b) an outboard seal establishing low pressure sealing with respect to said relatively rotata  
4 surface and defining a cooling chamber outboard of said second annular resilient sealing element;

5 (c) a cooling passage being disposed in fluid circulation communication with said cool  
6 chamber for circulation of said coolant fluid within said cooling chamber for cooling of said relativ  
7 rotatable surface and said second annular resilient sealing element.

1 9. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) a fluid circulation path being defined within said staging pressure chamber; and

3 (b) a fluid circulation system circulating fluid through said fluid circulation path at said stag  
4 pressure P2 for pressure staging and for removing heat buildup of said first and second annular resil  
5 sealing elements responsive to relative rotation of said relatively rotatable surface.

1 10. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) a bulkhead being disposed in sealed non-rotatable relation with respect to said housing

3 having a partition defining axially spaced annular seal carrier recesses;

4 (b) said laterally translatable annular seal carrier means being at least two seal carriers disposed  
5 within said axially spaced annular seal carrier recesses, each of said seal carriers defining an internal annular  
6 seal groove; and

7 (c) said annular resilient sealing elements each being seated within a respective internal annular  
8 seal groove and having interference sealing with said respective internal annular seal groove and with said  
9 relatively rotatable surface.

1 11. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 a fluid circulation passage being defined by said housing for circulating said second fluid therethrough  
3 removing heat build-up resulting from rotation of said relatively rotatable surface with respect to said first  
4 and second annular resilient sealing elements.

1 12. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 (a) a sealing interface being defined by engagement of said first and second annular resilient  
3 sealing elements with said relatively rotatable surface; and

4 (b) at least one of said first and second annular resilient sealing elements having a non-circular  
5 hydrodynamic geometry for wedging lubricant into said sealing interface responsive to rotation of said  
6 relatively rotatable surface.

1 13. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:

2 at least one journal bearing being defined by said laterally translatable annular seal carrier means  
3 establishing a guiding relationship with said relatively rotatable surface.

1 14. The laterally translatable pressure staged shaft sealing mechanism of claim 13, comprising:

2 (a) a said laterally translatable annular seal carrier means defining at least one opening  
3 therethrough;

4 (b) fluid circulation through said at least one opening; and

5 (c) said fluid circulation reducing pressure drop across said journal bearing.

1 15. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 bearing means positioning said laterally translatable annular seal carrier means with respect to :  
3 relatively rotatable surface.

1 16. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 (a) said laterally translatable seal carrier means being substantially hydraulic force balanced  
3 the axial direction.

1 17. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 said laterally translatable annular seal carrier means being a single seal carrier supporting said first  
3 second annular resilient sealing elements.

1 18. The laterally translatable pressure staged shaft sealing mechanism of claim 1, comprising:  
2 means circulating said first fluid for cooling of said first and second annular resilient sealing elements.

1 19. A laterally translatable pressure staged shaft sealing mechanism comprising:  
2 (a) a housing being exposed to a first fluid at a pressure P1;  
3 (b) a relatively rotatable surface being located for rotation with respect to said housing;  
4 (c) laterally translatable annular seal carrier means being laterally movable relative to :  
5 housing responsive to lateral movement of said relatively rotatable surface;  
6 (d) first and second annular resilient sealing elements being supported in axially spaced relat  
7 by said laterally translatable annular seal carrier means and having interference sealing relation with :  
8 annular laterally translatable annular seal carrier means and with said relatively rotatable surface  
9 defining a pressure staging chamber having a fluid at a pressure P1; and  
10 (e) means communicating a second fluid at a pressure P2 into said pressure staging chambl  
11 said pressure P2 being a fraction of said pressure P1.

1 20. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:  
2 (a) a bulkhead defining axially spaced annular seal carrier recesses; and  
3 (b) a force balancing system establishing substantially hydraulic force balancing of :

4 bulkhead in the radial direction to minimize pressure induced deformation thereof.

1 21. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 (a) a bulkhead defining axially spaced annular seal carrier recesses; and

3 (b) said laterally translatable annular seal carrier means being at least two seal carriers disposed  
4 respectively within said axially spaced annular seal carrier recesses.

1 22. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 said seal carriers being substantially pressure balanced in the radial direction.

1 23. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 (a) an outboard seal establishing sealing with said relatively rotatable surface and defining  
3 cooling chamber;

4 (b) a cooling passage being disposed in fluid circulation communication with said cooling  
5 chamber for circulation of coolant within said cooling chamber for cooling.

1 24. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 a fluid circulation system circulating fluid within said pressure staging chamber for cooling at least one  
3 said first and second annular resilient sealing elements.

1 25. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 (a) a sealing interface being defined by engagement of said first and second annular resilient  
3 sealing elements with said relatively rotatable surface; and

4 (b) at least one of said first and second annular resilient sealing elements having a non-circular  
5 hydrodynamic geometry for wedging lubricant into said sealing interface responsive to rotation of said  
6 relatively rotatable surface.

1 26. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:

2 said laterally translatable annular seal carrier means being a single seal carrier supporting said first  
3 second annular resilient sealing elements.

1 27. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:  
2 means circulating said first fluid for cooling of said first and second annular resilient sealing elements.

1 28. The laterally translatable pressure staged shaft sealing mechanism of claim 19, comprising:  
2 said pressure P2 being less than half of pressure P1.

1 29. A laterally translatable pressure staged shaft sealing mechanism for sealing of a relatively rotatable  
2 surface with respect to a housing and being exposed to first fluid at a pressure P1, comprising:

3 (a) bulkhead means establishing axially spaced annular seal carrier recesses;

4 (b) a plurality of seal carriers being located respectively within said axially spaced annular  
5 carrier recesses;

6 (c) a plurality of annular resilient seals being supported respectively by said axially spaced  
7 annular seal carriers and having interference sealing with said relatively rotatable surface;

8 (d) at least one annular staging chamber being defined between adjacent annular resilient seals  
9 and

10 (e) at least a second fluid at a staging pressure P2 being a fraction of pressure P1  
11 being in communication with said staging chamber.

1 30. The laterally translatable pressure staged shaft sealing mechanism of claim 29, comprising:

2 (a) said plurality of annular resilient seals being at least three annular resilient seals including  
3 first annular resilient seal and a last annular resilient seal;

4 (b) said first annular resilient seal being exposed to a first differential pressure; and

5 (c) said last annular resilient seal being exposed to a differential pressure which is less than  
6 first differential pressure.

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